Models in Physics

St Andrews
April 1981

Introduction

Phil. of Physics is concerned with methodology in general sense of an analysing the concepts, principles and ultimate presuppositions of physics.
this is all presupposed in P.I. & most texts in physics
pages — 1. — — — 200 deg upto foundations

3 main branches of Methodology
1.) Appraisal — Demarcation criterion
simplicity, testing theories etc
2.) Heuristics
3.) Conceptual analysis
— Analysis of simultaneity relations, concepts of ~~mass~~
definability of position & momentum of electrons etc
of course physicists do use .... the methodology to be applied & understand it — — —

2 Approaches
Prescriptive — formal — all sciences are alike
Descriptive
- keeps close to actual physics
- describes what goes on with a view to
a) Justification
b) Identifying intuitive elements

→ Models in physics < Analogy — [illegible] [illegible] [illegible] ; Theoretical [illegible] B-R

Analogy:

a) Formal: of electrostatic
potential ?
and. potential of an
~~incompressible~~ ideal liquid
in hydrodynamics
— same mathematical
equation — Laplace's Equation

$\operatorname{div} v = 0$ $v = \operatorname{grad}$.

b) Material: Billiard ball model
of a gas — same
actual particles assumed

Role of Analogy in explanation:
Explain unfamiliar in terms of the
familiar.

But now we tend to do the reverse

Explain the familiar in terms
of the unfamiliar.

— tendency to give up use of
models and analogies in
theoretical physics in general
and in particular in Q.T.

Models in Physics

10.00 **Introduction**

Literature Leatherdale, no references.
Taxonomy Taxonomy, Megamorph, paramorph, Teleiomorph etc

Two main types of model used in physics
Theoretical models – sort of inadequate theories
Analogue models – adequate theories about different objects or systems.

I confine myself to Theoretical models
a) cannot do everything
b) analogue models dropped out of modern Theor. Phys.

Two activities for philosophers of science

Foundational studies or methodology

1.) Describe what goes on in science accurately – examine arguments, lay bare logical structure, criticise them for inconsistency, logical gaps etc – tool is logic – This is what I shall be doing in this paper.

2.) Attempt more general Epistemological & ontological questions. Kant's Question – How is Science possible? How can theories be devised ~~life~~ for one group of phenomena & yet explain ~~predictions~~ correctly quite a different group.

Role of Analogy in Physics has been used in studying this second sort of question.
Both are legitimate.
My plea is that my more humble approach is not dismissed as irrelevant to Phil. of science

10.5

'satisfying' explanations
account for predictive growth of theories

Models in Physics

[Literature Leatherdale, 200 references
Taxonomy Harré, Homoeomorph, paramorph, Teleiomorph]

Theoretical models (Black, Models, Archetypes 1958)

Achinstein's Criteria slide ①

Believe models to be false, cf. Popperian account.

How models arise

Impoverishment

Enrichment

Model-independent theorems and $\left\{\begin{array}{ll} T_M \rightarrow T & \text{(quarks)} \\ T \rightarrow T_M & \text{(K.T.} \rightarrow \text{billiard ball model)} \end{array}\right.$

Models and Analogies slide ②

formal & material analogy.

$$\begin{tikzcd} T \arrow[r] \arrow[rr, squiggly, leftrightarrow] & T_M & T_A \arrow[l, squiggly] \end{tikzcd}$$

10.15 Models and approximations

cp $\left\{\begin{array}{l} \text{approximate solns exact eqs} \\ \text{exact solns approximate eqs.} \end{array}\right.$

slide ③ & ②a

N.B. (1) approximate eqs may have quite different solutions – instability

(2) Different Eqs may have same particular soln Ed $\frac{dy}{dx} - 7y = 0$ and $\frac{dy}{dx} - y = 0$ both have $y = 0$ as soln.

· Models have physical interpretation.

10.20 **Uses of Models**

(1) ~~Articulation~~ Probing of Theories slide ④ and ⑤

Tinker-toy models

*cf V. Weisskopf:

'A model is like an Austrian timetable. Austrian trains are always late. A Prussian visitor asks the Austrian conductor why they bother to print timetables. The conductor replies: If we didn't, how would we know how late the trains run?'

Quantum Pharmacology
W. G. Richards Butterworths 1977.

B. Josephson (1977) New Scientist. 23rd June.
" A theory of God need pose no serious problems to the modern physicist (in a first approximation, at any rate).

10.25 (2 **Heuristic Role of Models** slide (6)

Preferment
Enrichment
(cf relativity distracted from Maxwell's eqs)

S-matrix theory
Current algebra.
Gell-Mann Quotation p.12.

10.30 (3) **Testing of Theories** slide (7)

Empirical mathematics

Coincidence in Model predictions slide (8)

Not automatically sound, depends on reasonable prior confidence in adequacy of models.

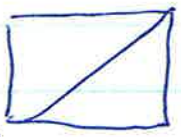
10.35 **Floating Models** *

~~(4)~~ **Farm Gate Contraction** slide (9)

Elliott model of nucleus
$H = H_{osc} + H_{Q\text{-}Q}$.

Floating Models of Projectiles slide (10)

Table top example



Zig-Zag models in Quantum Pharmacology

10.45 **Conclusion**

Science ~~is the~~ has been described by Medawar as art of the soluble.
~~Since theories in general are not soluble this can really be translated as Science is the Art of Modelling. Normal Science in the Kuhnian sense is~~, at the ~~theoretical~~ level,

Conclusion

Science has been described by Medawar as the Art of the Soluble. Since theories in general are not soluble, this can really be translated as Science is the art of Modelling. Normal science in the Kuhnian sense is at the theoretical level, largely concerned with this activity. Now Normal Science has sometimes been dismissed, by Popper for example, as a very 'dull affair'. This can be dispelled if the intuitive and imaginative elements in model-making are recognized as on a par even with the discovery of new paradigms. Modelling is certainly an Art although not perhaps the Black Art that some philosophers of science would have us believe.